Probing the Symmetry Term of the Nuclear Equation of State at High Baryonic Densities

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Abstract. In the ASY-EOS experiment flows of neutrons and light charged particles were measured for ^{197}Au+^{197}Au collisions at 400 MeV/nucleon, in order to investigate the strength of the symmetry term of the nuclear equation of state at supra-saturation densities. By comparing the experimental data with the UrQMD transport model predictions, we have extracted a new constraint in agreement with the moderately soft to linear density dependence obtained in the former analysis on FOPI-LAND data, but reducing the associated uncertainty by a factor ~ 2.

1. ASY-EOS experiment results

The neutron-proton elliptic flow ratio has proved to be an effective probe of the high-density behavior of the symmetry energy contribution to nuclear equation of state [1]. By comparing data for the Au+Au system from the FOPI-LAND experiment [2] with calculations performed with the UrQMD transport model [3], an estimate of a moderately soft to linear behavior of the symmetry energy was obtained, although with a considerable statistical uncertainty. The same data set was also compared to calculations performed with the Tübingen QMD model and a constraint compatible with the UrQMD result was obtained [4]. It is worth pointing that in the latter study different parameterizations of the isovector part of the equation of state, the Gogny inspired (momentum dependent) vs. the power law (momentum independent) potential, lead to

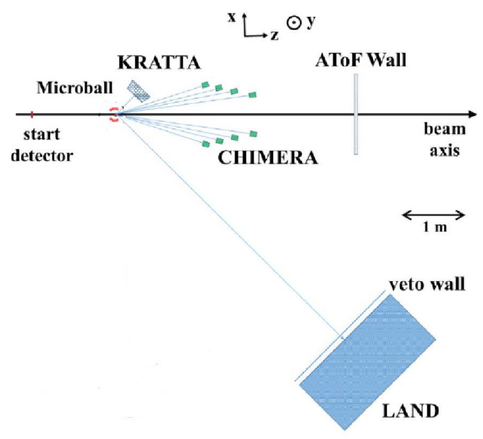

Figure 1. Schematic view of the experimental set-up of the ASY-EOS experiment at GSI.

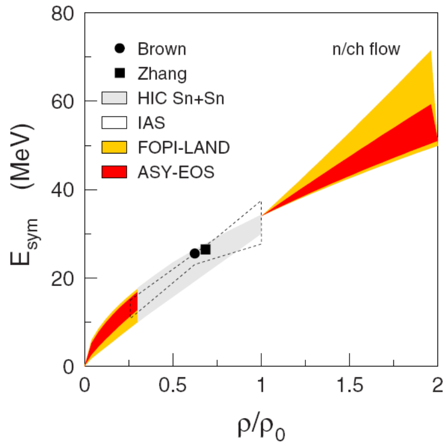

Figure 2. Constraints deduced for the density dependence of the symmetry energy from the ASY-EOS experiment in comparison with the FOPI-LAND result of Ref. [1] as a function of the reduced density ρ/ρ_0. See Ref. [10] for more details.

very similar results, suggesting the possibility to obtain a model independent constraint.
In order to improve the statistical accuracy, the neutron-charged particles elliptic flow ratio in the symmetric collision system ^{197}Au+^{197}Au at 400 MeV/nucleon incident energies was re-measured in the ASY-EOS experiment, carried out at the GSI laboratory in May 2011 (S394 experiment), by coupling the Large Area Neutron Detector (LAND) [5], the Krakòw Triple Telescope Array (KRATTA) [6], the ALADIN Time-of-Flight (AToF) wall [7], 8 rings of the CHIMERA multidetector [8] and 4 rings of the Washington-University Microball array [9], as schematically shown in Fig. 1. More details can be found in Ref. [10].
By comparing the experimental ratio with the UrQMD predictions, a value γ=0.72±0.19 is obtained for the power-law coefficient of the potential part of the symmetry energy parametrization adopted in the UrQMD model, as shown in Fig. 2 ; the density region probed is $\sim$ 1.5 ρ_0. This new result agrees with the older one from the FOPI-LAND data, but reduces by a factor $\sim$ 2 the total uncertainty.
The results of the ASY-EOS experiment confirms the effectiveness of the elliptic flows ratio in probing the symmetry energy at high-densities. We plan to extend such a kind of measurements at GSI to higher beam energies, up to $\sim$ 1 GeV/nucleon, in order to explore higher densities (up to about 2.5 ρ_0), profiting of the unique opportunity offered by the NeuLAND detector, presently under construction as part of the R3B experimental setup [11] and the availability of very asymmetric radioactive ion beams that will be delivered by the FAIR facility.

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